DMSO RESEARCH AND DEVELOPMENT FUNCTIONAL WORKING GROUP WORKSHOP

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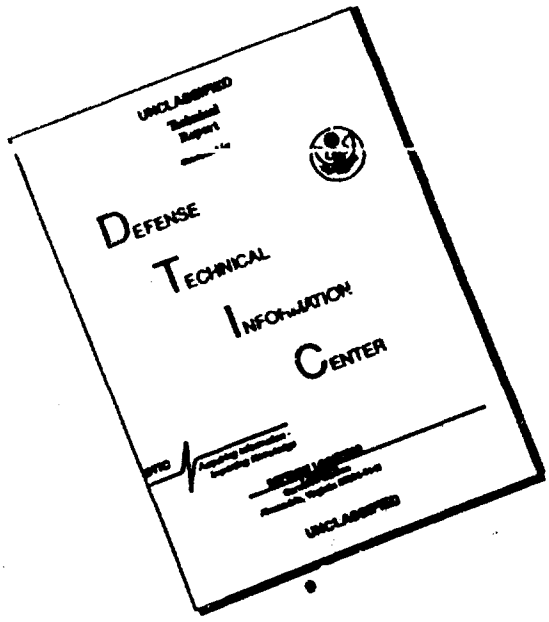

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During 1992, a series of workshops was conducted in support of the Defense Modeling and Simulation Office (DMSO) to determine the modeling and simulation (M&S) needs of the defense M&S community. This community is partitioned into five major areas: Education, Training and Military Operations (ETMO), Research and Development (R&D), Test and Evaluation (T&E), Production and Logistics (P&L), and Analysis. Each of these areas has a Functional Working Group (FWG) representing its interests to the DMSO and other interested parties. Workshops were conducted to assist the FWGs in determining the "requirements pull" to be considered in the development of the DMSO Master Plan.

This report presents the results of the Research and Development (R&D) Workshop for developing Modeling and Simulation (M&S) needs for the R&D community. The executive summary provides an overview of the background, objectives, organization, and summary results of the R&D Workshop. The body presents the workshop background and objectives, describes the working groups, process, and products, and provides an expanded summarization of the workshop results.

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REPORT ORGANIZATION

This report presents the results of the Research and Development (R&D)Workshop for developing Modeling and Simulation (M&S) needs for the R&D community. The executive summary provides an overview of the background, objectives, organization, and summary results of the R&D Workshop. The body presents the workshop background and objectives, describes the working groups, process, and products, and provides an expanded summarization of the workshop results.

The appendices represent the contributions of the individual work groups which were used to produce the final results. Appendix A lists the workshop participants by working group. Appendices B through F are the viewgraphs from the final reports on the five working groups.

EXECUTIVE SUMMARY

OBJECTIVES

The workshop's primary objective was to define the research and development (R&D) community's needs for M&S into the next century. The workshop emphasized needs common to the whole Department of Defense (DOD), and needs that applied to joint service/agency applications of M&S. Major needs that are unique to a service were also to be identified and documented. The secondary objective was to improve the communications within the R&D community concerning the utilization of M&S.

VISION OF M&S SUPPORT TO R&D

COL Fitzsimmons of the Defense Modeling and Simulation Office (DMSO) presented the DMSO vision of the use of networked simulators and simulations. Networking produced a revolution in the use of models, simulations, and simulators. This revolution brings the warrior back in the loop in the development of military capabilities for the DOD. The use of simulations and simulators to evaluate tactics and doctrine has already been extended to prototyping new capabilities through modeling the new capabilities as modifications to simulations of current capabilities. The use of prototyping simulators is expected to support the product development that achieve second and third generation capabilities from the product's first generation.

The workshop's vision of M&S is the use of M&S for early identification and selection of promising technologies. Physical representations of new technologies will be included in combat models and simulations to demonstrate the military impact of the new technologies. Networking of models and simulations will also be applied to the R&D process. Detailed physical models will be networked together to combine electronic, materials, aerodynamic, environmental, and other phenomena models to achieve higher levels of fidelity without recourse to ever larger individual physical models.

METHODOLOGY: WORK GROUP PRODUCTS

The workshop was tasked to develop prioritized lists of M&S needs for R&D. Session 1 identified roles and types of M&S used in each participant's organization and major problems typically encountered. Session 2 defined M&S support needed by the R&D community in the future. Session 3 compared and prioritized the needs identified. On the afternoon of the third day, each chairman briefed his working group's list of M&S needs for R&D to the entire workshop. Chairmen and co-chairmen then met in executive session to achieve consensus.

EXECUTIVE SESSION CONSENSUS: DIRECTION AND TOOLS FOR M&S SUPPORT TO R&D

To meet the vision of using M&S to identify promising technologies, the R&D community needs top down direction on the appropriate methodologies to be used to make comparisons. Each R&D center wants to evaluate new technologies and systems on a "level playing field" so that the results at each center are directly comparable to the results from other centers. By using DOD established methodologies, each center will ensure that the center selects the most promising technologies and programs in the R&D center's area of expertise.

The top down guidance must be supported by an "infrastructure" of universally available M&S tools. A M&S "library" function is critical to ensure the accessibility to the M&S tools. In addition to providing access to existing tools, the infrastructure must sponsor R&D to create new M&S capabilities and establish standards to use the new capabilities. This top down management function should sponsor or fund the "infrastructure" as a DOD-wide R&D resource.

PRIMARY NEEDS IDENTIFIED BY WORKSHOP

A set of M&S standards is the highest priority R&D need. Standardized models and simulations with standardized formats for input and output are needed to extend the capability to use the models and simulations across the community. Documented data bases and scenarios that have been approved through an accepted verification, validation, and accreditation (VV&A) process are needed to drive the standard models and simulations.

A "library" function is needed that includes the capability to distribute VV&Aed models, simulations, and data bases. The workshop found that many individual M&S capabilities existed, but could not be used to full potential due to access problems. The M&S library will provide access without requiring extensive training to merely execute the models.

VV&A support through an established methodology and with automated tools is the third major need identified by the workshop. The representation of new technologies requires the modification of models, simulations, data bases, and tools obtained from the "library". Each modification requires VV&A to ensure the correct application of the model or simulation.

Need for Top Down M&S Direction

Top down direction is needed on the appropriate methodology to be used to compare technologies. M&S practitioners at all levels will use established tools and procedures to compare alternatives and select the most promising approaches to the most critical problems and needs. The M&S technology selection methodology will include, but not be limited to, three elements. First, standard models and simulations accompanied by data bases that represent standard scenarios provide a "baseline" to compare new technologies. Second, a standard methodology to change the baseline to represent the new technology. Third, a standard set of measures and tools to support the evaluation of the potential payoff of new technologies.

M&S Infrastructure Support to the R&D Community

A centralized infrastructure organization is needed as part of the M&S support to the R&D community. The development, review, and "publication" of standards for application across DOD R&D should be directed as a DOD function, not simply assumed by an individual R&D center.

The infrastructure functions will include identification of a family of standard models that satisfy the R&D community needs. Each model will be verified and validated. The accreditation of a model and data base for a particular use will be accomplished through published standard procedures. Modifications of data bases by members of the R&D community will follow standardized data formats, and definitions. The combination of multiple models and/or simulations will employ standardized model interfaces, or interface data processors, to allow the output on one model or simulation to be used as input to another model. Man-in-the-loop simulators will use infrastructure-defined (e.g., Distributed Interactive Simulation, DIS) protocols to pass information across a network of models, simulations, and simulators.

Verification and validation (V&V) methodologies and tools will be used to establish the range of applicability of models, simulations, data bases, and scenarios that will be modified to represent new technologies, systems, or subsystems. Accreditation methodologies and tools will be used to accredit the specific applications of each model and simulation. Accreditation tools and methodologies will include a statistical analysis capability to support the evaluation of input data and simulation results. V&V tools will help the accreditation process by testing for whether or not the "validated" range of the input data includes the range for the particular program requirements.

Standardizing, collecting, verifying and validating models and simulations will have limited payoff if the results are not available across the R&D community. A library of models, data, and tools will make M&S available across the DOD R&D community. The library will include users' tutorials and tools that provide access to all the aspects of M&S applications. A M&S modification environment will be one of those tools that supports the development of variants of the M&S "library" products. The validation and verification of modified models and simulations will allow the modified models and simulations to become part of a growing M&S library.

M&S Applications for R&D

Several M&S tools and functions will be broadly applicable to the DOD R&D community. Such tools include hardware to place diagnostic outputs directly into data bases. The continued growth of data, will require standardized data base manipulation packages or environments to analyze data. Automated tools will manipulate data bases with complex data objects and discrete data values.

When a new technology is being researched and developed, the developers will modify and enhance existing models and simulations to represent the new technology. A M&S "workbench" of tools will support data and model modification, verification, and validation. The "workbench" will include training aids to allow R&D practitioners to use the "workbench" without relying on M&S specialists.

In addition to tools that will modify current M&S capabilities, tools are needed that will support the translation of laboratory and field test data into M&S input data. Also, tools are needed to translate M&S output data back into laboratory and field test diagnostic parameters. The flow of data between test results and M&S will both improve the utility of test data and improve model validation and accreditation.

An example of a particular technology with wide R&D application is the development of multi-spectral scene generators to support the R&D of new sensors. These scene generators will include both multi-spectral standardized, or approved scenario, "backgrounds" and multi-spectral targets. Other physical models will be developed based on the need by multiple R&D projects. The further development of Project Reliance allocation of areas of responsibility or similar mechanisms will be used to avoid duplication of M&S development efforts.

Management of M&S Support to the R&D Community

Oversight management will be required to establish M&S standards, the "library", and other tools to facilitate the M&S support to R&D. Management will also identify and direct the development of new R&D oriented models and simulations. The M&S infrastructure also needs a centralized "advocate" of M&S support for R&D. The M&S "advocate" will coordinate and represent the M&S support community's funding requirements within the DOD funding process. In the course of justifying the M&S infrastructure cost structure, the M&S support to R&D management will also function as a centralized management center for the development of new capabilities in M&S technologies.

In summary, to avoid wasteful duplication of M&S efforts and to achieve M&S capabilities not justified by individual R&D programs, the M&S infrastructure will take the responsibility for planning for the future of M&S support to R&D.

INTRODUCTION

WORKSHOP OBJECTIVES

PRIMARY

- **Define R&D community's needs for M&S support**

  into the next century

  - **Include consideration of supporting capabilities**
  - **Emphasis on common and joint needs**
  - **Major service-unique needs captured also**
  - **Look toward the future**

SECONDARY

- **Amplify and provide background for major needs**
- **Inform community about what is going on in M&S**
  - **New technology and its creative application**
  - **New initiatives and on-going programs**
- **Form connections/links across and between workshop participants**
  - **Share information about how M&S is used**

WORKSHOP OBJECTIVES

There were both primary and secondary objectives for the workshop for modeling and simulation (M&S) needs to support research and development (R&D).

The primary objective was to define the R&D community's needs for M&S into the next century. These needs included M&S support, e.g., data bases, computer hardware capabilities, etc. The workshop attendees were requested to emphasize needs common to the whole Department of Defense (DOD), and needs that applied to joint service/agency applications of M&S. Major needs that are unique to a service were also to be identified and documented.

The workshop participants were asked to consider future needs that will arise from continued improvements in M&S supporting technologies, as well as needs that will evolve out of projected research developments.

The secondary objective was to improve the communications within the R&D community concerning the utilization of M&S. The workshop sought to establish and amplify the background for how M&S is used to support research in key DOD technologies. This workshop tried to both inform the R&D community and establish communications links within the R&D community on M&S applications. Workshop participants covered a wide range of technologies and programs. Discussions on the applications of M&S to new technologies, to new initiatives, and to on-going programs provided a chance for participants to share information on the uses of M&S.

VISION OF M&S SUPPORT TO R&D

- **Networked simulators, simulations, and constructive simulations are producing a revolution in the applications of M&S to military problems and issues**
- **M&S "prototyping" of new technologies could be used to identify the best technologies and technical applications for the DOD and support simulated prototyping to ensure the faster development of a better product**
- **Sharing of physical simulations can support both research into new technologies and the development of new applications for those technologies**
- **The development of linked simulators and simulations for R&D is an opportunity to transfer new capabilities from the DOD to the civilian community**

VISION OF M&S SUPPORT TO R&D

COL Fitzsimmons of the Defense Modeling and Simulation Office (DMSO) presented the DMSO vision of the use of networked simulators and simulations. Networking produced a revolution in the use of models, simulations, and simulators. This revolution brings the warrior back into military capabilities development. The networked use of simulations and simulators to evaluate tactics and doctrine has already been extended to prototyping new capabilities. The use of prototyping simulators will support product development that achieves second and third generation capabilities from the product's first generation.

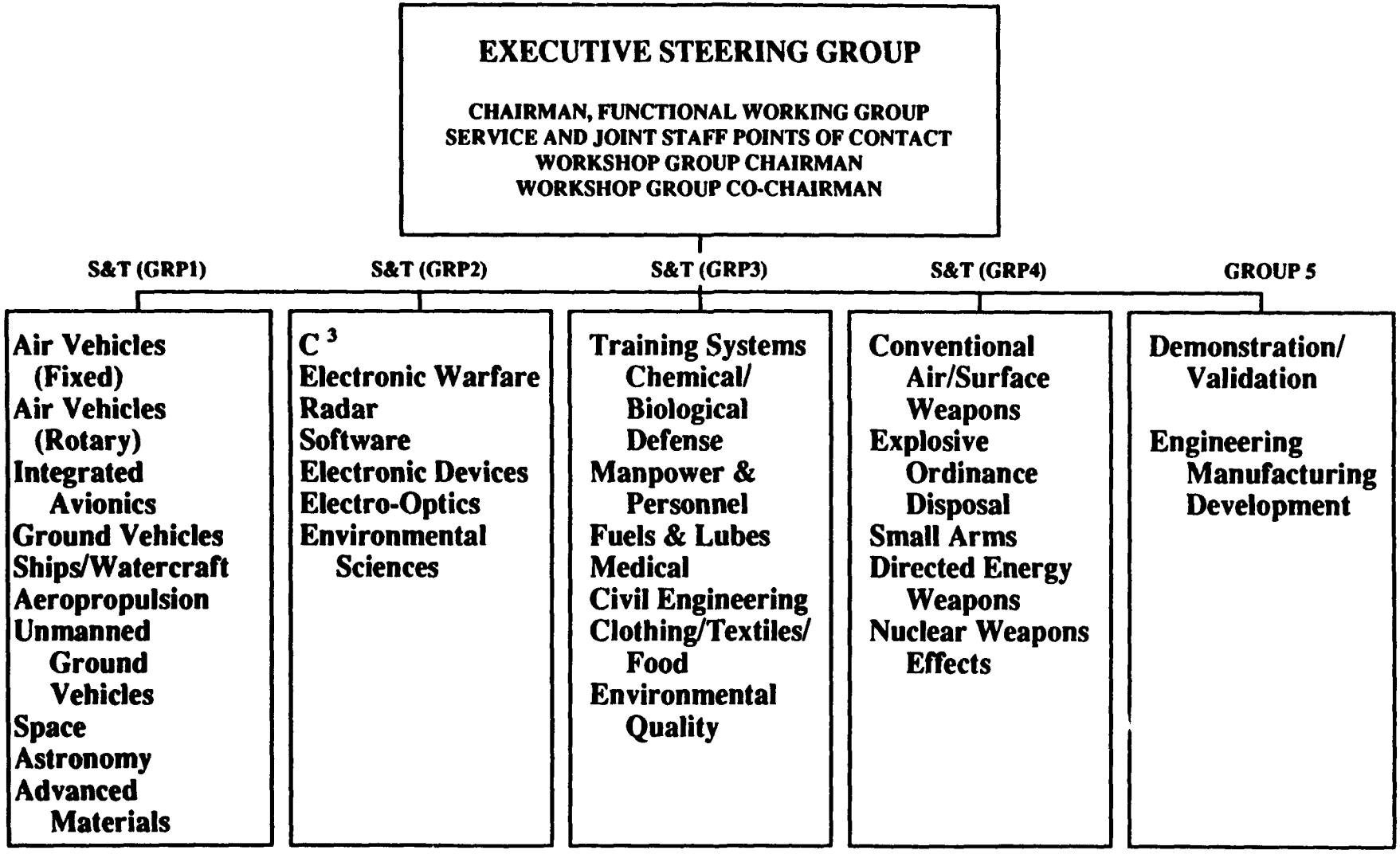
The workshop's vision of M&S is the use of M&S for early identification and selection of promising technologies. Physical representations of new technologies will be included in combat models and simulations to demonstrate the military impact of the new technologies. Networking of models and simulations will also be applied to the R&D process. Detailed physical models built with standardized data and data formats will be networked together to combine electronic, materials, aerodynamic, environmental, and other phenomena models to achieve higher levels of fidelity without recourse to ever larger individual physical models.

The use of simulations and simulators to evaluate tactics and doctrine has already been extended to prototyping new capabilities through modeling the new capabilities as modifications to simulations of current capabilities. The linking of subsystems to systems to units provides force effectiveness data to support system optimization. Prototyping simulators will support product development. Force effectiveness, suitability, and performance of each technology development will be determined from the modeling of multiple prototypes in simulated combat. M&S will provide both faster and more relevant evaluation of emerging technologies that will lead to better allocation of R&D resources.

The military paradigm of networked M&S will also be applied to the physical simulations of new physical processes. Individual R&D centers have their own models and simulations. Networking physical models will support the development of new technologies in the context of a broader range of detailed physical models. Physical models will be networked together to combine electronic, materials, aerodynamic, environmental, and other phenomena to achieve higher levels of system engineering, analysis, and evaluation capabilities without recourse to ever larger individual models.

The linking, or interoperability, of models, simulations, and simulators by the DOD community is a DOD-unique technology. Applications of M&S capabilities to R&D for both technology and product development has applications to the civilian community. Therefore, as new ways are developed to use M&S to support R&D, the R&D community will identify promising tools and capability for civilian applications.

WORKING GROUP COMPOSITION



WORKING GROUP COMPOSITION

The R&D Workshop was divided into five working groups. Groups one through four encompassed the R&D areas for science and technology (S&T) identified in the Tri-service Reliance in Science and Technology document prepared by the Joint Directors of Laboratories. The fifth group was drawn from R&D interests focused on engineering manufacturing development and demonstration/validation.

The intent was to form the workshop from a broad representative crosssection of the R&D community. Specialty areas were combined into working groups that had maximum cohesion. Almost all of the Tri-service Reliance in Science and Technology specialty areas were represented.

METHODOLOGY: WORK GROUP PRODUCTS

Session 1

- List of M&S roles now and in the future
- List of M&S types now and in the future
- Collection of M&S problems typically encountered

Session 2

- List of future M&S needs to support R&D
- Notation of expected critical issues in fulfilling

Session 3

- Final list of M&S needs compared to other workshops
- Prioritized list of near-term (0-5 years) needs
- Prioritized list of long-term (>5 years) needs

METHODOLOGY: WORK GROUP PRODUCTS

Three days were allocated to develop near- and far-term prioritized lists of M&S needs for R&D.

The morning of the first day was devoted to orientation, DMSO, DARPA, S&T Thrust 6, and previous M&S needs workshops briefings. A detailed approach to identifying needs was presented to achieve the workshop objectives. Each group met separately for sessions 1 through 3.

The objective of session 1 was to identify roles and types of M&S used in each participant's organization and major problems typically encountered. Each member of each group described current and projected M&S roles in the member's organization. Each member described major problems in the use of M&S in the member's organization. The chairman of each group presented briefings summarizing each group's roles, types, uses, and problems in the use of M&S to the entire workshop on the second day.

Session 2 defined all M&S support needed by the R&D community in the future. Each group considered M&S needs in three different phases. First, what is needed prior to executing a model or simulation? For example, what models are available? Second, what M&S needs arise during the execution of selected models or simulations? And finally, what needs arise after execution?

The objective of session 3 was to compare and prioritize the needs identified within each group. Each group was provided lists of M&S needs identified by the "analysis community", the Test and Evaluation Workshop, the Education Training, and Military Operations Workshop, and the Production and Logistics Workshop. The list of prioritized needs were to be grouped into near-term needs for zero to five years and long term needs for five or more years.

On the afternoon of the third day, after session 3, each chairman briefed his working group's list of M&S needs for R&D to the entire workshop.

After the working group briefings, the chairman of the DMSO R&D functional group met in executive session with the chairmen and co-chairmen of each working group to achieve the consensus results reported below.

EXECUTIVE SESSION CONSENSUS: DIRECTION AND TOOLS FOR SUPPORT TO R&D

- Top down direction on how M&S is to be used for selecting alternative technologies, subsystems, and systems
- M&S infrastructure to support use of M&S by R&D community
  - "Library" of models, simulations, data, and scenarios
  - "Library" of standards for the use of M&S
  - "Library" of tools to use models, simulations, and data
  - R&D of new M&S capabilities and standards
- Specific models and simulations to enhance the use of M&S in R&D
- Top level managerial support of M&S support to R&D

EXECUTIVE SESSION CONSENSUS: DIRECTION AND TOOLS FOR SUPPORT TO R&D

During the executive session of the workshop chairmen and co-chairmen, the need for both "management" and "functional" M&S support to R&D was recognized. "Management support" is defined to include managerial functions that include selection of standards, allocation of areas of responsibility, implementation of policies and procedures, and communication of results/decisions. "Functional support" is defined to include providing models, simulations, data bases, research to develop standards, M&S development tools, and other software/hardware needed to provide M&S support to the R&D community with a focus on military user needs. In other words, M&S support needs to be both managed and substantive to engineer and evaluate advanced technology that meets user mission needs and operational requirements.

This slide summarizes a four point M&S "support structure" to enhance the use of M&S by the R&D community. Only two of the four bullets directly reference what is typically thought of as modeling and simulation. The first bullet and the last bullet refer to "management" directed establishment of procedures and the management of M&S resources. The balance between the need for new M&S tools and models and the need for new ways for organizations to use and fund M&S was one of the most striking results of this workshop.

To meet the vision of using M&S to identify the preferred technology, subsystem, or system, the use of M&S to support the R&D community first needs direction on the appropriate methodologies to be used to make comparisons. Each R&D center wants to evaluate new technologies and systems on a "level playing field" so that the results at each center are directly comparable to the results from other centers. To achieve a "level playing field," uniform methodology, tools, and measures of success need to be developed at the direction of top levels of the DOD and published for use by the services and the R&D centers.

The management provided guidance must be supported by an "infrastructure" of universally available M&S tools. These tools, described in greater detail below will include the hardware and software typically required to run and operate models and simulations as well as enhanced access tools to obtain and use the models and simulations. A M&S "library" function will be critical to providing accessibility to the M&S tools. The infrastructure also will direct and/or conduct R&D to create new capabilities and establish new standards to use the new capabilities.

The workshop did not develop a list of needed specialized algorithms, models, or simulations. However, several new or enhanced capabilities were identified as needed to model and simulate the technologies being studies and developed by multiple members of the R&D community.

As resources are always limited, and M&S support crosses program lines, there should be a separate M&S management function that supports the M&S "infrastructure" for the DOD. This management function will refine the development of M&S capabilities across the DOD, sponsor or find dollars to support the "infrastructure," and fund the development of M&S technology.

PRIMARY M&S NEEDS IDENTIFIED BY WORKSHOP

- Standards
  - Standard models and simulations that are VV&Aed
  - Standard data bases and scenarios
  - Standard protocols to establish interconnectivity
- "Library "(repository, distribution, and trainer) of M&S support to the R&D community
  - VV&Aed models, simulations, and data bases
  - Tools to modify models, simulations, and data bases
  - Tools to VV&A modified models, simulations, and data bases
  - Training on the use of M&S
- VV&A capabilities
  - Standard procedures to accomplish VV&A
  - Automated tools to support the VV&A process
- Scenarios

PRIMARY NEEDS IDENTIFIED BY WORKSHOP

This slide summarizes the top four priorities identified by both the separate work groups and the executive session of the chairmen and co-chairmen.

The highest priority is the need for M&S standards. Validated and verified standard models and simulations are needed as a starting point. Approved data bases and scenarios are needed that will drive the models and simulations. Standard data definitions and formats are required to allow the transport of models and simulations between R&D centers. Interfaces and data protocols will be established to allow the networking of models and simulations. Open-system architectures will be defined for the system, subsystem, and physical/technology interface levels.

Many M&S capabilities exist, but cannot be used to their full potential due to access problems. A "library" function is needed that will included the capabilities to distribute VV&Aed models, simulations, and data bases; and to provide training. The access function of the "library" will include standardized documentation of all tools. Tutorials will be part of the documentation to provide any required training by the M&S practitioner.

Models, simulations, data bases, and tools from the library will be modified as part of the individual R&D program. When a M&S tool is modified, it will require VV&A to ensure the results are appropriate for comparison to results from other R&D programs and projects. VV&A support will include an established methodology and automated tools to implement that methodology .

Finally, "approved" scenarios will be used to represent the application of new technologies and systems to realistic operational situations. When a new technology or system points to the implementation of new tactics and doctrine, established scenarios will be supplemented and modified to represent the appropriate utilization of the new technology. Use of man-in-the-loop simulators will be an important aspect in the development of these new tactics and doctrine that lead to new scenarios for the utilization of proposed technologies and systems.

NEED FOR TOP DOWN M&S DIRECTION

- Centralized guidance
  - Avoid duplication of effort
  - Develop standards for entire R&D community
  - Identify M&S technologies applicable across R&D community
- Standardized M&S methodologies for identifying promising technologies, subsystems, and systems
  - Standard scenarios, models, and simulations
  - Standardized methodologies to represent technologies, subsystems, and systems
- Standard M&S tools to be used within the methodology
- Standard measures supported by the tools

NEED FOR TOP DOWN M&S DIRECTION

Top level direction is needed to ensure a broad use of M&S across R&D centers and across services. The R&D community has a long history of developing specialized M&S tools to support the conduct specific R&D programs. The multiple use of M&S tools, and particularly the rational selection or prioritization of R&D requires top down guidance and direction. Such guidance will focus the use of M&S and avoid the duplication of effort in the construction and VV&A of models and simulations. Standardized data formats; protocols to link models, simulations, and simulators; and standards development all require centralized direction. In addition to standards, the identification and development of M&S technologies to support the entire R&D community require a centralized organization that tracks the R&D community's evolving needs and the development of M&S technologies. Without direction, individual R&D centers cannot provide such direction.

The R&D community needs direction on the appropriate methodology, or methodologies, to be used to compare technologies, systems, and subsystems. The establishment of tools and procedures to compare technologies will let practitioners at all levels select the most promising alternative. The methodology to use M&S to make selections will include three elements. First, a standard baseline consisting of models and simulations accompanied by data bases that represent standard scenarios. Second, a standard methodology will be used to incorporate the new technology, system, or subsystem into the baseline. And third, standard measures of merit or effectiveness will be used to rank order the predicted pay off of each technology.

Standard M&S tools to implement the methodology will also be identified. M&S development environments will be used to modify sections of a model or simulation to represent the technical change. Automated validation and verification tools will be used to ensure the correct technical representation of a new technology. M&S tools will include standard environmental models. As no model or simulation is functional without data, a standard scenario and data base that represents the scenario is also required. Methodologies and procedures to modify the scenario to represent the tactics and doctrine that a new system can exploit will require tools that can draw on military expertise to develop proposed tactics and doctrine.

After a new system, subsystem, or technology is introduced to a scenario, the researcher still needs to know what are the critical issues associated with the scenario, and what are the measures how well those issues are addressed. A standard set of measures, within the context of provided methodologies and tools will allow the R&D community to evaluate potential payoff of projects and programs. Since the methodologies and measures are standardized, then standardized data base extraction tools can be used to extract, organize, and present data.

M&S INFRASTRUCTURE SUPPORT TO THE R&D COMMUNITY

- Standards
  - Develop
  - "Publish"
  - Maintain
- Standard models
  - Identify
  - V&V and provide accreditation procedure
- Data
  - Standard data definitions and formats
  - Standard model and simulator data interfaces
- Standard protocols to network models and simulations
- Standard VV&A tools
- Accessible support — "library" to models, data, and tools

M&S INFRASTRUCTURE SUPPORT TO THE R&D COMMUNITY

M&S support to the R&D community needs centralized organization and direction. The development of standards for application across DOD R&D is too broad to be the responsibility of a single R&D center. The organization of projects to develop specific standards also requires centralized control. Once a standard is developed, it will require review to ensure community-wide applicability and utility. After review, the central organization for R&D support becomes a clearinghouse, or "publisher" of the new standard. Finally, as new technologies and requirements develop, the standards will be reviewed for adequacy and updated as required.

A family of models that satisfy the R&D community needs will be identified. Once identified, each model will be verified and validated for future use. The accreditation of a model or simulation for a particular use will be accomplished through a standard procedure that will be available to the R&D community.

Standard models can only be used if standardized data bases are available to drive the models. Modification of the M&S input data by members of the R&D community requires the use of standardized data formats, and definitions. The combination of multiple models and/or simulations will also require standardized model interfaces, or interface data processors, to allow the output from one model or simulation to be used as input to another model. The use of man-in-the-loop simulators will require the establishment of protocols to pass information across a network of models, simulations, and simulators.

Perhaps the most critical standards requirements are those associated with the verification and validation (V&V) of models and simulations. Accreditation of a particular simulation to the requirements of a particular program will be the responsibility of the program manager or of those who review the program. The difficulty of V&V of models and simulations for all cases limits the context of V&V. Accreditation tools are also needed. Accreditation tools can include a statistical analysis package to ensure the range of the input values are consistent with test situations that the model or simulation is replicating. V&V tools can help accreditation by testing whether or not the "validated" part of the input data ranges includes those proposed for the particular program.

Standardizing, collecting, and V&Ving models and simulations will be wasted effort if the results are not available. M&S will be made available through a "library" of models, data, tools, and methodologies. The "library" need not be a centralized structure, instead it could be an electronic mail listing of products and points of contact. The "library" should include access tools to all the aspects of M&S. For M&S modifications, a M&S modification environment will support the development of variants of the "M&S library" products. In addition, the "library" will provide tutorial tools and facilities to train personnel on the use of any "library" item.

M&S APPLICATIONS FOR R&D

- Data processing
  - Faster, cheaper, and more efficient
  - Tools to track modifications of VV&Aed data bases
- Simulation modification tools that are easy to use
  - Analyst's "workbench" to modify models and simulations
  - Automated tools to VV&A modifications
- Tools to integrate laboratory and "field" test diagnostic data into simulations and simulators
- Multi-spectral scene generators to support R&D of new sensors
  - Standard, multi-spectral, scenario driven scene backgrounds
  - Standard, multi-spectral complex targets integrated into scene
- Other physical models applicable to multiple R&D projects

M&S APPLICATIONS FOR R&D

Faster and cheaper data processing techniques are needed by the entire R&D community. Such tools include hardware to interface test diagnostic outputs directly into data bases. Automated techniques are needed to create and modify complex data objects and discreet data values in large data bases. With increased use of M&S, larger amounts of data will be generated: this data will require standardized data base manipulation packages or environments to analyze data and report the relevant results.

When a new technology, subsystem, or system is being researched and developed, existing models and simulations will be enhanced to represent the new technology, subsystem, or system. Input and output data will be reviewed and modified. A model and simulation "workbench" of tools will be needed to support data and model modification, verification, and validation. The workbench environment will include training to allow use by all R&D professionals, not just M&S experts.

In addition to tools that modify current M&S capabilities, automated tools will translate laboratory and field test data into M&S data bases. Also, tools will translate M&S output data back into test parameters of specific diagnostics.

One particular technology that has a wide R&D application will be multi-spectral scene generators to support the R&D of new sensors. These scene generators will include both multi-spectral standardized, or approved scenario, "backgrounds" and multi-spectral targets. The "complexity" of both the target and "background" will reflect the expected resolution capabilities of different sensors.

Other physical models will be developed based on the need by multiple R&D projects. The further development of Project Reliance allocation of areas of responsibility or other mechanisms will avoid duplication of efforts and ensure the efficient development of models at centers of modeling excellence.

MANAGEMENT OF M&S SUPPORT TO THE R&D COMMUNITY

- **Oversight management of M&S support to R&D**
- **Centralized advocate for funding M&S infrastructure support**
- **Centralized management of funding of R&D of M&S technology**
- **Centralized planning for future of M&S support to R&D**

MANAGEMENT OF M&S SUPPORT TO THE R&D COMMUNITY

The establishment of a "library", standards, and other tools to support the use of M&S by R&D, and the development of new R&D oriented models and simulations will require oversight management. The day-to-day operation and maintenance of these capabilities will also require management.

Beyond setting up and operations of M&S support functions, the M&S support will be a centralized "advocate" of M&S support for R&D. The M&S "advocate" will coordinate and represent the M&S support community's funding requirements within the DOD funding process.

In the course of justifying the M&S infrastructure cost structure, the M&S support to R&D management will also function as a centralized management center for the development of new capabilities in M&S technologies.

In summary, to avoid wasteful duplication of M&S efforts and to achieve M&S capabilities not justified by individual R&D programs, the M&S infrastructure will take the responsibility for planning for the future of M&S support to R&D.

APPENDIX A

PARTICIPANTS LIST

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APPENDIX B

GROUP 1 REPORT

Modeling & Simulation Needs for Research & Development

Group 1

Overview

Needs for successful outcomes

- Front end planning and proper preparation
- Verification, Validation, and Accreditation of each model in the internetted simulation
- Proper selection of the models used
- Scenario preparation
- Long term management sponsorship

Problems

- Overselling
- Modeling and simulation as the product
- Excessive/undefined collection of data
- Selection of models with fidelity/resolution limitations
- Caution is urged in the VV&A process to assure models are improved

Approach and Preliminary Findings

Approach

- User of model
- Developer of models

Preliminary Findings

- Technology available to achieve large scale simulation networks
- Assemble teams with cross disciplinary expertise

Pre-Execution Near Term Needs

- Training to use model
- Library
  - Industry
  - security
  - users groups
  - accepted data base (regional data bases)
  - test cases
  - lessons learned
  - communications
- Need common scenarios
  - Joint scenarios with service support/sign-up
  - User responsibility for currency, common environment, weather, littoral shallow water, etc.
- VV&A
- Wide band links

Pre-Execution Long Term Needs

- Funding, resources
- Futuristic scenarios, need for POC for joint future scenarios
- Streamline acquisition process for M&S technology access
- Institutionalize large scale internetted simulations
- Simulation support tools
  - Simulation imagery
  - Rapid prototyping
- M&S Training for senior leadership and through the ranks

Pre-Execution Critical Issues

- Funding (Near & Long term)
- Detailed standardized joint scenario(s)
- Qualified personnel
- Maintaining state-of-the-art
- Network of high frequency events
  - Latency
  - Message traffic
- M&S Training for senior leadership
  M&S Training thru the ranks

Execution Near and Long Term Needs

- On-line QA
- Data collection/reduction
  - On-line data capture (network vs stand-alone)
- Real-time scene dynamics
- Standards, Protocols, and Common Interfaces for Interoperability
- Increasing processing power and computation speed of h/w and s/w
- Understanding limitations of M&S (overselling)

Execution Critical Issues

- Real-time high fidelity sensor simulation
- Dynamic environment/terrain representation
- Infrastructure for large scale internetted systems not yet mature if it exists
- Common software modules
- Visual display systems
  - high fidelity
  - resolution
  - processor speed/update rates
  - field of view
  - 3-D

Post-Execution Near Term Needs

- More emphasis on analysis
- Formalizing lessons-learned
- Output visualization/formalization
- Data extraction
  - discrete
  - tabulation
  - Configuration management of data files
  - collection plan
- Immediate after action feedback
- Model caveats/statement of assumptions

Post-Execution Critical Issues

- Long term planning (continuity)
- Data processing techniques
  - data extraction
  - data analysis
  - data base management
  - management of output data from different simulations
- Facilitate lessons-learned collection / retrieval
- Documentation
- Multi-level security

Post-Execution Long Term Needs

- Compute power
- Technology transfers/insertions
  DOD <--> Commercial
- Update and upgrade to state-of-the-art
- Central archive of simulation files and data bases
- Data processing techniques
  - data extraction
  - data analysis
  - data base management
  - management of output data from different simulations

General M&S Critical Issues

- R&D of M&S in support of P&L (-ilitites analysis)
- M&S investment strategy
  - central/government facilities
- Underutilized defense contractor facilities
  - personnel,equipment
- Develop/support long term in-house facilities
- Improved M&S for decision support along the acquisition cycle
  - M&S for risk reduction
- Need for formal education in academia and Services
- Multi-level security
- Communications

Short List

- Library
- Joint, Common, Future Scenarios
- Standards, Protocols, Common Interfaces
- Data processing techniques

Unique R&D Characteristics

What is unique about the R&D community regarding models and simulations

- The tech base used in M&S is produced by the R&D community and applied by all communities
- For M&S the R&D community is on the high end of the spectrum in
  - use of first principles science based M&S
  - temporal resolution requirements
  - resolution of detail
  - need for diagnostics information (why something happened)
  - weapon system life cycle cost impact (most of cost is determined at end of concept definition)
  - leveraging M&S research capability of industry
  - freedom to explore variations
- For M&S, the R&D community is in the low end of the spectrum
  - predefined requirements

Crosswalk of Stated Needs

Working Group	Correlation
Test and Evaluation	High
Education, Training, and Military Operations	Medium
Production and Logistics	Low
Analysis	High

APPENDIX C

GROUP 2 REPORT

Modeling & Simulation Needs for Research & Development

Group 2

M&S Roles

Summary of M&S Roles Typical of Participants

Looking At:		
• Concepts	• Prototypes	• Existing Systems
Exploration and Assessment of:		
• Doctrine and Tactics	• Systems of Systems	• System Integration
• Systems	• Processes	• Information Flow
• Sub-systems	• Components	• Technologies
In the Context of:		
• Mission	• Threat	• Environment
Against Criteria of:		
• Warfighting Effectiveness	• System Performance	• Feasibility
• Staff Reqs/Human Perf	• Logistics Demands	• Risk Assessment
• Cost	• RAM	• Safety

M&S Roles (Concluded)

Representative Examples of M&S-based Explorations

- Engineering Analysis
- Understanding
- Investment Strategy
- Trade-off Studies
- Environmental Quality
- Electromagnetic Env Effects
- Target Simulators
- Compatibility & Integration
- Experimental Design
- Documentation of System
- Weather/Environment
- Multi-Spectral Propagation
- System Stimulation
- Threat System Modeling

Additional Future Roles

- Stimulate Data Collection
- Software Performance
- Systems/Procedure Design for Non-Traditional Missions/Roles

M&S Types

Dimensions of M&S

- Stochastic vs Deterministic
- Man-in-Loop vs Interactive vs Batch
- Real Time vs Non-Real Time
- Pure Math Models vs Dynamic Simulations
- Discrete Event vs Continuous
- Event Driven vs Time Stepped
- Functional vs Object-Oriented
- Stand-Alone vs Networked

M&S Types (Concluded)

M&S Pyramid

- **Policy**
- **Theater**
- **Campaign**
- **Engagement**
- **System**
- **Engineering Component**
- **Physics and basic science**

M&S Problem Areas

- **Non-Standardized, Validated or Accredited:**
  - **Models** – **Scenarios** – **Environment Data**
  - **Red/Blue/Grey DB** – **Doctrine Rep** – **Human Performance**
- **Lack of CM** • **Poor Maintainability** • **Life-Cycle Cost**
- **Lack of *Information* on Available Model Capabilities**
- **Over reliance on Contractors for M&S**
- **Fundamental Knowledge** • **Visualization** • **Environmental Rep**
- **Execution Inefficiency** • **Portability** • **Interoperability**
- **M&S Installation and Operational Complexity (Usability)**
- **Lack of Good Quality Empirical/Field Data**
- **Models Available Often Inappropriate for their Desired Use**
- ***Data Transmission Needs often Exceed Transmission Bandwidth***
- **Voice Data Capture and Generation**
- **Access to Black System Capabilities** • **MLS**

M&S Needs - Pre-Execution Activities

- Find the model or build the model
- Acquire/develop the data base
- Define/select the scenario
- Problem definition
- Evaluation criteria
- Identify critical issues for model coverage test plan
- Validate (VV&A)
- Find resources
- Define inputs and outputs
- Manage expectations

M&S Needs

- Model Libraries and Repositories
  - On-line information clearinghouse
  - Easily accessible products
  - Centers of expertise (on models and applications)
  - Centralized coordination & distributed implementation (proponents)
  - Multi-level Security
- Data Repositories
  - On-line information clearinghouse
  - Easily accessible products
  - Standardized and accredited
  - Centralized coordination & distributed implementation (proponents)
  - Multi-level security (including proprietary and sensitive data)
  - Rainbow spectrum of force data

M&S Needs (Continued)

- Standardized VV&A process, procedures and policy
  - Models and confederations of models
- Education and training for M&S and data users (DOD-sponsored)
  - Civilian and military career path integration
  - Training materials and user handbook
- Common DOD M&S architectures
  - Portability
  - Simulation control standards
  - Standard SW and languages
  - Open systems including reference model
  - Simulation control standards
- Increased awareness of management and leadership

M&S Needs (Continued)

- Advanced Simulation Support Environment
  - Graphical User Interface
  - Object/Class Libraries
  - Automated data introduction
  - Scenario development tools
  - Audit Trail
  - Automatic report generation (with graphics)
  - Tools to estimate resource requirements (HW, Comm)
  - Assist in data capture

M&S Needs (Continued)

- Scenario definition and repository
  - Multiple levels of scope (combined — one-on-one)
  - Approved/accepted
  - Realistic and stressful environments
  - Multi-level Security
  - Automated/electronic

M&S Needs (Continued)

- Runtime monitoring, reduction, & presentation
- Better, faster graphics
- Faster execution
- Real-time environmental data
- More flexible HW & SW procurement policy
- R&D access to warriors and training & testing exercises
- R&D community involvement in DIS PDU definition
- M&S should cover complete spectrum of military & non-military operations

M&S Needs (Continued)

- Understanding of what raw data should be retained
- Faster data reduction — including video and audio
- Capturing lessons learned into repository
  - Model development
  - Model use
  - Feeds back to M&S requirements
- Interoperability
  - DOD-wide
  - Interface and documentation standards (DIDS)
  - Multi-domain/discipline M&S

M&S Needs (Continued)

- Hypermedia
- Adequate funding for
  - Simulation technology
  - Infrastructure
- Procurement policy appropriate for need & potential of M&S
  - Mandatory use of M&S
  - Data rights
  - Acquisition strategy

M&S Needs (Concluded)

NEW MODEL FUNCTIONALITY

- Model of human behavior in C2 (decision making including variability)
- Standardized environmental models
- Multispectral visualization
- Dynamic spatial resolution
- Natural/man-made environmental dynamics

M&S Long-Term Needs

- Next generation simulation support environment
  - Intelligent Simulation Management Tool
  - Intelligent Simulation Maintenance Aid
- Seamless interfaces between simulations & outside world
  - Multiple resolution levels
  - Multi-echelons
- Standardized data journaling capabilities embedded in M&S (user selectable)
- Supplement M&S with embedded instrumentation and field data collection

Modeling & Simulation Needs for Research & Development

Results

GROUP 2

High Priority Near-Term Needs (ORDERED)

Adequate funding assumed for:
- **Simulation technology**
- **Infrastructure**

- **Standardized VV&A process, procedures and policy**
  - **Models and confederations of models**

- **Model Libraries and Repositories**
  - **On-line information clearinghouse**
  - **Easily accessible products**
  - **Centers of expertise (on models and applications)**
  - **Centralized coordination & distributed implementation (proponents)**
  - **Multi-level security**

- **Model of human behavior in C2 (decision making including variability)**

High Priority Near-Term Needs

- Data Repositories
  - On-line information clearinghouse
  - Easily accessible products
  - Standardized and accredited
  - Centralized coordination & distributed implementation (proponents)
  - Multi-level security (including proprietary and sensitive data)
  - Rainbow spectrum of force data

- Interoperability
  - DOD-wide
  - Interface and documentation standards (DIDS)
  - Multi-domain/discipline M&S

High Priority Near-Term Needs

- Common DOD M&S architectures
  - Portability
  - Simulation control standards
  - Standard SW and languages
  - Open systems including reference model
  - Simulation control standards

- Standardized environmental models

Medium Priority Near-Term Needs

- Education and training for M&S and data users (DOD-sponsored)
  - Civilian and military career path integration
  - Training materials and user handbook
  - Increased awareness by management and leadership
- Scenario definition and repository
  - Multiple levels of scope (combined— one-on-one)
  - Approved/accepted
  - Realistic and stressful environments
  - Multi-level security
  - Automated/electronic
- R&D community involvement in DIS PDU definition
- Faster data reduction — including video and audio

Modeling & Simulation Needs for Research & Development
Group 2

Medium Priority Near-Term Needs

- Advanced Simulation Support Environment
  - Graphical User Interface
  - Object/Class Libraries
  - Automated data introduction
  - Scenario development tools
  - Audit trail
  - Automatic report generation (with graphics)
  - Tools to estimate resource requirements (HW, Comm)
  - Assist in data capture

Medium Priority Near-Term Needs

- Capturing lessons learned into repository
  - Model development
  - Model use
  - Feeds back to M&S requirements
- Procurement policy appropriate for need and potential of M&S
  - Mandatory use of M&S
  - Data rights
  - Acquisition strategy
- Natural/man-made environmental dynamics
- Faster execution
- Real-time environmental data

Low Priority Near-Term Needs

- M&S should cover complete spectrum of military & non-military operations
- Dynamic spatial resolution
- Runtime monitoring, reduction, & presentation
- Better, faster graphics
- More flexible HW & SW procurement policy
- Understanding of what raw data should be retained
- Hypermedia

Prioritized Long-Term Needs (Ordered)

- Next generation simulation support environment
  - Intelligent Simulation Management Tool
  - Intelligent Simulation Maintenance Aid
- Seamless interfaces between simulations & outside world
  - Multiple resolution levels
  - Multi-echelons
- Supplement M&S with embedded instrumentation and field data collection
- Standardized data-journaling capabilities embedded in M&S (user selectable)

M&S Needs - Critical Issues

- People not available
- Corporate vision
- Communication between activities/people
- Education of developers/implementors, users, and decision makers
- Mission definition flux
- Distributed network management managing confederation of net members
- Collect data on human C3 decision-making behavior
- Simulation technology PE (service & DOD)
- Adequate funding for:
  - Simulation technology
  - Infrastructure
- Data needs defined, responsibilities fixed, timelines established, data base populated
- More efficient code, powerful HW and high-speed communications networks
- Advantageous utilization of distributed processing

APPENDIX D

GROUP 3 REPORT

Modeling & Simulation Needs for Research & Development

Results

GROUP 3

M&S Types

- Training
- Manpower/Personnel
- Medical
  - Operational Combat Medicine
  - Health Risk Assessment
  - Basic Biomedical Sciences
  - Man Machine Interface
- NBC
- Civil Engineering
- Environmental Quality
- Textile/Food
- Fuels and Lubricants

M&S Problem Areas

Technical Problems Identified in Topical Subjects

- Inadequate Software "Ilities" and Configuration Management
- Deficient VV&A
- Inadequate Warrior Models
- Modelers Are Data Poor, Simulators Are Measure Poor
- Insufficient Tools
- M&S Inventory Problem
- Visualization and Graphic Display of Results

M&S Problems (concluded)

Management Problems

- Models and Simulations Are Poorly Defined
- Developers, Owners and Users Not Clear
- Stovepipe Approach to M&S Development and Use
- Care and Feeding of Infrastructure (People and Resources)
- M&S Phobia at the Top, Paradigm Shift Needed

Training - Pre-Execution

- Good definition of the problem or the goals the simulation must address
- Iterative, pro-active participation/interface between user & designer/bu ilder
- Consistent policy to work toward common goals of interoperability exchange, and use/reuse by a 'community of users' vice single user where possible
- Clear achievable standards as goals for all to strive to
- Data bases - usable, changeable, and compatible
- M&S tools to build training
- Library - inventory assistance,
  - VV&A of M&S,
  - Access tools
- User - Need - Requirement - Result user ⇔ modeler ⇔ simulator
- Access Tools
  - multi-use,
  - flexible fidelity and low cost

Training - Pre-Execution (Continued)

- Visible -ilities (VV&Aed)
- Standards
- Vision — Strategy — Policy
- Man-Machine Interface
- Behavioral models
- Determine data collection requirements

Training - Execution

- Iterative feedback from user in a timely fashion, coupled with iterative feedback involving DMSO
- Joint Policy/Guidance that forces joint communications, data exchange and realistic tests/demos of interoperability
- Develop and maintain joint test beds which are reconfigurable and/or adaptable for different scenarios/uses
- Auto data collection/processing
- Intrusion while executing
- Monitoring system (ID suspect areas)

Training - Post-Execution

- Review of simulation used
  - Meet requirements (fidelity, reliability, maintainability in support of training??)
  - Can it be adapted / used / reused for other users?
- Commitment / Decision on follow-up (kill project, add to it, "export" to commercial use, etc.)
- Review for "common concepts" and MOE
- Data processing / transfer
- Documentation/ VV&A update system
- Configuration management
- CAD / CAM concurrent engineering standard output

R&D Training Needs

- Training testbed that allows seeing, doing, & learning with enough realism
- Testbeds that are flexible & modular (including scenario and data base generation) that are user friendly
- Task/training specific models of human subsystems (e.g., visual, cognitive, proprioceptive, ergonometric models)
- Measurement and feedback methods linked to task & training objectives
- Methodology for projecting simulation and modeling needs for training use

Manpower / Personnel

- Force, organization, duty cycle, and functional trade-off models (including Reserve, National Guard integration)
- Manpower allocation by system and function
- Methods of modeling workload including crew/team interaction
- Determinants of combat success including motivation, cohesion, and other sociological issues
- Classification and testing models

Modeling & Simulation Needs for Research & Development
Group 3

Health Risk Assessment Needs

- Interaction of multiple "stressors" on individual
  - Biological - chemical warfare
  - Industrial environment
  - Environmental quality
  - Life-cycle costs of acquisition

Modeling & Simulation Needs for Research & Development
Group 3

Operational/Combat Medicine

- Skills enhancement in wartime scenarios, battlefield wounds/injuries, "virtual" cadavers
- Logistics/supplies/skills/equipment packages specific to scenario/threat
- Remote delivery of skills
  - surgeon @ medical center in communication with medic in field

MEDICAL

Impacting manpower/personnel training

- Casualty streams
- Workplace safety/injury
- Ergonomics
- Infectious disease
- "Environmental" stresses, heat, cold, etc.
- Health promotion//intervention
  - Drugs & alcohol
  - Physical fitness

Basic Biomedical Sciences

- Integration of anatomic functional, biochemical paradigms of brain function
- Vaccine development
- Molecular biology
- Enhanced performance drugs
- Rest-sleep cycles

Modeling & Simulation Needs for Research & Development
Group 3

Man-Machine Interface

- Validated life science/physiological models
- High performance AC enclosed environments
- Human factors
- Aircraft accident reconstruction
- Bio-mechanical

Modeling & Simulation Needs for Research & Development
Group 3

NBC

- Multiple problems of handling combined wounded & NBC contaminated casualties from triage to cure
- Preventive NBC
  - Future threat agents
  - Future threat cures
- Light weight/ breathing combined contaminate bullet proofing
- Better NBC Detection Sensors
- Accurate Environmental Models

Modeling & Simulation Needs for Research & Development
Group 3

Civil Engineering

- Multiple-use Joint Services test beds for VV&A
- Visualization capabilities for voluminous input / output data
- Common conceptual basis to help simulation developers
- Upgrade material / interaction models
- Develop facility / mission relationships
- Modeling human factors/perceptions
- Standardized architecture for heterogeneous data bases
- Improve model efficiency (vectorize, adaptive grids)
- Develop accurate failure models
- Expert systems for damage assessment
- Concurrent engineering models for facility acquisition

Modeling & Simulation Needs for Research & Development
Group 3

Environmental Quality(EQ)

- Common conceptual basis for modeling environmental quality related processes
- Object-oriented geographic information system that can handle both raster and vector information
- Object-oriented M&S environment that integrates procedural and declarative programming
- Rapid prototyping capability (simulations)
- Corporate environmental quality knowledge / data bases
- EQ "executive agent"
- Better understanding of the physical and biological processes affecting EQ
- Better understanding of how to model sociological aspects of EQ

Textiles / Food

- Individual warrior model and simulations
  - Link high resolution item/component models to low resolution, macro theater-level simulations
  - Facilitate DOD technology investment decisions for Thrust 8
  - Optimize combat effectiveness for the individual combatant
  - Assess impacts on survivability resulting from changes in warfighter equipment, training, and doctrine
- User friendly interface
  - Facilitate development
  - Reduce start up effort
  - Saves time & resources
- Automated forces — eliminate any requirement for other nodes to be "present" when running simulations and R&D excursions

Textiles / Food (Continued)

- Electronic catalog — data base of what's available & POCs / instructions for use / help
- Multiple use models — address multiple requirements / problems with single application
- Standard framework for scenario excursion
  - Ability to explore options — desert, arctic, etc

Fuels / Lubricants / Consumables

- Campaign-level modeling to identify logistics problems in sustainment
  - Replenishment requirements
  - Bulk storage requirements
  - Distribution requirements — need year's inventory
  - Threat proof
  - Methods / doctrine to shrink requirements weight/cube (dehydration)
- Environmental safety/occupational health
- A/C fuel system virtual prototyping
  - Leak avoidance

Wrap-Up

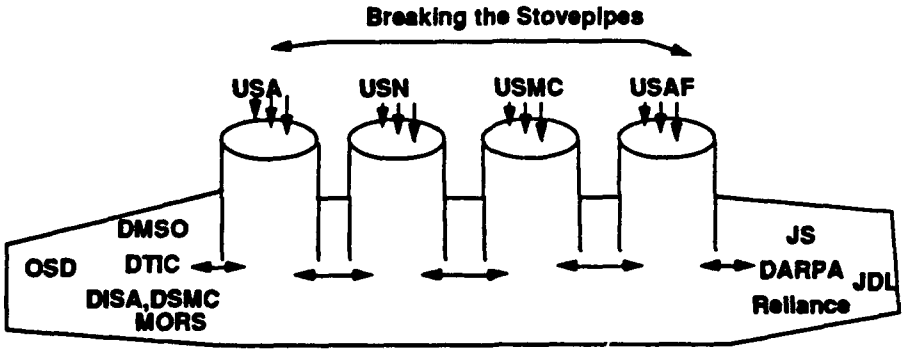
- How Did It Work? Quite Well!
  - Group adopted a solutions-oriented approach early on
- What Worked Particularly Well?
  - Organization into subgroup speciality areas
  - Point Man ("Expert") in each area to develop products
  - Concurrent overview to distill solutions that apply across the board
- What Didn't Work Well?
  - Diversity of Topics
  - Group felt that each subgroup was worthy of consideration as its own working group
- Recommendations: Are solution oriented
- Our Question: To what extent will recommendations be adopted?

Modeling & Simulation Needs for Research & Development
Group 3

	PRE-EXEC	EXEC	POST EXEC
NEAR TERM	ID problem based on current S-T-T-P (related to scenario/threat) Customer problem - conceptualize approach Customer/analyst/ modeler IF interface - pragmatic approach Applications tool box - multiple use models, data M&S Policy -- COEA/ORD/TEMP Desk top reference	ID solutions establish VV&A, A = analyst Address solution based on customer MOE MOS MOP Upgrade - model application - reduce data deluge using MOE, SP, analysis Approach	ID better solutions/VVA; delete non solutions - customer satisfied? - new customer/owner? - what was decision support provided by M&S? Update applications toolbox
FAR TERM	Top-down M&S standards for Systems (to put load on TGT) Combat, combat support, Combat service support Driven by: - strategy(policy) - tactics (force level) - Systems (Campaign model) - Subsystems (Engineering models)	Technology solutions based on - systems (putting load on target) using present (data)/defining deficiency projected (data)/establishing needs, tactics Strategy-Policy-(Scenario/Threat) Still applicable? "Library" update	Update policy as appropriate Provide DOD desktop reference Update standards "library"

Modeling & Simulation Needs for Research & Development
Group 3

Information Flow Paradigm



Problems --> Solutions

Problem: Models and Simulations are Poorly Defined

- **Near-term Solutions**
  - **M&S to support warfighter system**
  - **Establish top-down applications tool book**
    - **multiple use models**
    - **appropriate data**
    - **M&S policy for COEA/ORD/TEMP**
    - **user-oriented desktop reference**
  - **Base on strategy-tactics-technology-policy related to scenario/threat**

- **Far-term Solutions**
  - **Establish (top-down) M&S standards for decision support**
    - **M&S for Strategy/Policy Decision Support**
    - **M&S for Force Level Tactics Decision Support**
    - **M&S for Campaign Outcome for Systems Decision Support**
    - **M&S for Systems Engineering at Platform Level**
    - **Combat Systems (put lead on target)**
    - **Combat Support Systems**
    - **Combat Service Support Systems**
    - **M&S for Engineering (to physics) at Subsystem Level**
    - **Data Management based on the above**

Modeling & Simulation Needs for Research & Development
Group 3

Problems --> Solutions

P: Developers, owners, and users not clear

S: Involve owners and users by providing solutions to strategy/tactics/ technology deficiencies (user focus)

S: Define role of owner/user and interaction with Decision Support Force

- **System Engineer**
- **Evaluator/Analyst**
- **Modeler/Coder**
- **Tester**

Problems --> Solutions

P: Stovepipe Approach to M&S Development/Use

S: Educate acquisition force at DSMC (customer/user; decision maker/decision support force)

S: Orient DOD M&S directive to customer/user desktop reference on M&S

S: Make better use of information sharing by Military Operations Research Society

Problems --> Solutions

P: Reluctance to use M&S by top-level Management

S: Base technology solutions on current top-level strategy-tactics-technology (needs) /future scenario threat

S: Take top-level solutions to top-level executives

S: Make top-level solutions understandable

S: Educate top level executives as they come up through the pipeline
- DSMC
- service schools

S: Implement paradigm by providing user (decision maker) with understandable graphics visualization of statistical outcome

Problems --> Solutions

P: Care and feeding of infrastructure

S: Include M&S decision support work force in DAWIA training

S: Train decision support force at DSMC
- system analyst/operations researcher
- modeler/simulations developers

S: Provide resources to train and retain highly qualified infrastructure

Critical Issues

- MAINTAIN USER PERSPECTIVE
  - Know who user (customer) is
  - Know what his strategy/tactics are
  - know what decision support user needs
  - Know difference between decision support team and user
- BREAK DOWN STOVE-PIPES (NOT ENOUGH IPPD)
  - Production and logistics (P&L) community absence
  - Range community absence
  - Analytical community absence
- TOP-LEVEL LEADERSHIP TO INSTITUTE M&S
  - Policy
  - Resource allocation
  - Education
  - User involvement in the process

BOTTOM LINE: USER FOCUS! USER FOCUS! USER FOCUS!

APPENDIX E

GROUP 4 REPORT

Modeling & Simulation Needs for Research & Development

Results

GROUP 4

M&S Roles

- Requirements generation and validation
- Concept validation
- Sub-system performance and design
- Technology demonstration and development
- Software design and validation
- Testing and training

M&S Types

- Digital
- Hardware-in-the-loop
- Man-in-the-loop
- Distributed Interactive Simulation
- Hybrid (analog/digital representations)
- Physical effects models (e.g., computational fluid dynamics)

M&S Problem Areas

- Inability to identify what is available in the community
- Lack of standards across the community
- Lack of available highly capable user friendly tools that can be used across a broad set of computer platforms
- Current engineering approaches to model development limits reusability
- Current simulation cannot be used to meet the emerging requirements of the new world situation (e.g., joint regional conflict)
- Lack of communication/coordination of developers and application

M&S Problem Areas (Continued)

- Lack of concurrent simulation (in terms of performance, producibility, logistics, testing, and training)
- Computational speed is still a limitation for a class of R&D simulations
- Lack of adequate sources of truth for validation
- Data/databases
  - Lack of data
  - Knowledge of available data
  - Validation/certification
- Sensor simulation for hardware in the loop
  - Multispectrum
  - Clutter background
  - Countermeasures
  - Complex targets
- Ability to model behavioral representation

M&S Policy Problems

- Lack of a consistent clear multi-year objective and vision (R&D simulation infrastructure)
- Inability to maintain simulation expertise in a climate of resource reductions (e.g., personnel, budgets)

Prioritized Near-Term Needs

Top Level Methodology

- Need to develop M&S top level approach for R&D including model/simulation suitability/applicability
- Requirement to include all design factors (performance, cost, produceability, logistics, etc.) into integrated M&S methodology/approach to support the entire acquisition life cycle
- Development a process to define Operational Situation circumstances from which scenarios can be drawn with the objective of defining factors such as environment, order of battle, tactics, threats, etc.
- Process needs to focus on producing a highly flexible method for assessing rapidly changing scenarios which provides the basis for clear statement of M&S objectives
- Need to identify appropriate Measures of Effectiveness to be used in Synthetic Environments that represent a spectrum of joint operations to assess the value added as a result of technology alternatives and enhancements

Prioritized Near-Term Needs

Infrastructure

- Develop standards which address:
  - Documentation
  - Configuration Management
  - VV&A
  - Architecture

  to achieve interoperability across simulation environments (virtual, constructive, real) and software reusability, transportability and share-ability
- Establish methodologies and procedures for verification and validation for levels of simulation accepted by the services

Prioritized Near-Term Needs

Infrastructure (Continued)

- Create robust Distributed Interoperable Simulation
  - Reconfigurable simulator to support virtual prototyping
  - Methodology to reflect fidelity from lower level simulations into DIS
  - Computer generated forces/Human behavioral representation
  - Virtual Reality — porting the individual into the environment
  - Dynamic Environment representation
  - Configuration testing for network assets
  - Display technology
  - Intelligent gateways/bandwidth
  - Correlation techniques for dissimilar simulator linkage

Modeling & Simulation Needs for Research & Development
Group 4

Prioritized Near-Term Needs

Infrastructure (Continued)

- Requirement to establish standards for databases, a data dictionary and procedures for accrediting (traceability) data, also methodology how to deal with data voids

  Database tool to automatically provide data based on level of simulation fidelity

  Database tool needs to address the M&S architecture consideration to provide required data
- Need a electronic M&S library which can be used to provide M&S user a catalog of existing validated M&S, documentation, databases, software modules and an assessment of use/limitation

  Need to develop an A/I tool to support query of model catalog

  Need software source code repository as standardization becomes a way of life

Prioritized Near-Term Needs

R&D S&T World

- User friendly simulation development tools and run time environment are required
  - speeds development
  - enhances user understanding of technology capability
  - reduces errors
- Develop advanced target/environment presentation system for hardware-in-the-loop simulation

  Needs to address multispectrum, clutter background, configuration management, countermeasures, etc.

  To conduct evaluation and testing of developmental hardware in a laboratory environment
- Develop common support models for: threats which provide performance characteristics, countermeasures, multispectrum signatures, and environmental representations of clutter, background, atmosphere, etc.

Modeling & Simulation Needs for Research & Development
Group 4

Prioritized Near-Term Needs

- Number 1: Standards (Infrastructure)
- Number 2: Top Level Approach for R&D (Top Level methodology)
- Number 3: Concurrent Engineering (Top Level Methodology)
- Number 4: VV&A Methods & Procedures for Reusability (Infrastructure)
- Number 5: User Friendly Tools and Environment (R&D S&T)
- Number 6: Scenarios for Joint Operations (Top Level Methodology)
- Number 7: Representation System for HITL (R&D S&T)
- Number 8: Robust DIS Synthetic Environment (Infrastructure)
- Number 9: Common Support Models (R&D S&T)
- Number 10: Database Standards/Dictionary (Infrastructure)
- Number 11: MOEs (Top Level Methodology)
- Number 12: M&S Library/Tools (Infrastructure)

Critical Issues

- Development/retention of simulation expertise
- Clear multi-year vision/objective for the M&S community (Line item investment strategy)
- Interservice cooperation for information exchange in M&S
- Reusability isn't taken serious — Remains fiction
- Suitability of force-on-force to measure military worth of S&T products

M&S Needs

1 Development of Joint Operational Scenarios

Need a process to define Operational Situation circumstances from which scenarios can be drawn with the objective of defining factors such as environment. order of battle, tactics, threats, etc.

Process needs to focus on producing a highly flexible method for assessing rapidly changing scenarios which provides the basis which provides the basis for clear statement of M&S objectives

This should should be viewed as a starting point to a process. Unless we look at this as an entire process our efforts will be able to be merged together

Although scenario generation is typically seen as a policy issue — issued to the Services as part of the DG —it is our view that there are technologies that can be brought to bear in a process to help those policy makers provide quickly, more detailed, meaningful scenario data to the M&S community

This would greatly enhance focusing the M&S effort to make them more suitable and applicable to the study effort

M&S Needs (Continued)

2 Need to identify appropriate Measures of Effectiveness to be used in Synthetic Environments that represent a spectrum of joint operations to assess the value added as a result of technology alternatives and enhancements

3 Requirement to include all design factors (performance, cost, produceability, logistics, etc.) into integrated M&S methodology/approach to support the entire acquisition life cycle

4 Develop advanced target/environment presentation system for hardware-in-the-loop simulation. Needs to address multi-spectrum, clutter background, configuration management, countermeasures, etc.

To conduct evaluation and testing of developmental hardware in a laboratory environment

5 Establish methodologies and procedures for verification and validation for levels of simulation accepted by the services

M&S Needs (Continued)

6 Requirement to establish standards for databases, a data dictionary and procedures for accrediting (traceability) data, also methodology how to deal with data voids

Database tool to automatically provide data based on level of simulation fidelity

The database tool needs to address the M&S architecture consideration to provide required data

7 Develop standards which address:

- Documentation
- Configuration Management
- VV&A
- Architecture

to achieve interoperability across simulation environments (virtual, constructive, real) and software reusability, transportability and share-ability

M&S Needs (Continued)

8 User friendly simulation development tools and run time environment are required
- speeds development
- enhances user understanding of technology capability
- reduces errors

9 Need a electronic M&S library which can be used to provide M&S user a catalog of existing validated M&S, documentation, databases, software modules and an assessment of use/limitation

Need to develop an AI tool to support query of model catalog

Need software source code repository as standardization becomes a way of life

M&S Needs (Concluded)

10 Create robust Distributed Interoperable Simulation
- Reconfigurable simulator to support virtual prototyping
- Methodology to reflect fidelity from lower level simulations into DIS
- Computer generated forces/Human behavioral representation
- Virtual reality — porting the individual into the environment
- Dynamic environment representation
- Configuration testing for network assets
- Display technology
- Intelligent gateways/bandwidth
- Correlation techniques for dissimilar simulator linkage

11 Develop common support models for: threats which provide performance characteristics, countermeasures, multispectrum signatures, and environmental representations of clutter, background, atmosphere, etc.

12 Need to develop M&S top level approach for R&D including model/simulation suitability/applicability

APPENDIX F

GROUP 5 REPORT

Modeling & Simulation Needs for Research & Development

Results

GROUP 5

Grouped Roles of M&S

1. Technical
- Engineering design tradeoffs
- Test driver (DT/OT) (2)
- Test design
- Development & evaluation of design concepts
- Human factors engineering (2)
- Performance analysis and projections (2)
- "ilities" impact assessment – produceability, maintainability, reliability, supportability, survivability, vulnerability, shop floor layout, (all)
- Safety analysis (2)
- Accident analysis (2)
- Concepts tradeoffs (all)
- Security (essential technology protection)

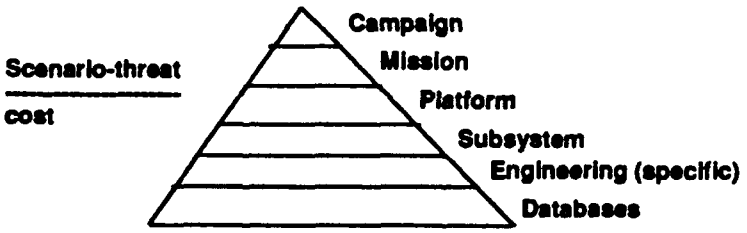
Grouped Roles of M&S

2. Operational
- Requirements refinement
- Tactics development
- Nuclear safe escape weapons delivery (1)
- Conventional safe escape weapons delivery (1)
- Mission planning

3. Economic
- Cost & schedule projection and analysis (economic model) (4)
- COEA (4)
- Analytical basis of investment strategy (4)
- Affordability/quantities analysis

4. Management
- Audit trail of acquisition process (1)

M&S Types in Member's Organization



Grouped M&S Problems

1. **Technical**
   - Lack of interoperability (4)
   - Imprecise knowledge of physical process (physics)
   - Lack of data element description (4)
   - Inadequate/incorrect resolution (granularity issue)(3)
   - Poor user interaction practice during model dev (2,4)
   - Imprecise vocabulary (4)
2. **Operational**
   - Imprecise requirement definition (4)
   - Requirement instability (4)

Modeling & Simulation Needs for Research & Development
Group 5

Grouped M&S Problems

3. **Economic**
   - Cost growth (4)
   - Resource competition (M&S vs other uses of resources (4)
   - Resources to set up model to run (4)
   - Inadequate resources (funding, manpower/skills, equipment, facilities, *mgmt commitment*) (4)

Grouped M&S Problems

4. Management

   Configuration control (documentation, etc.)

   VV&A (high cost & lack of method) (3)

   Standards

   Imprecise "approved" scenarios (or no approved scenario) (2)

   Lack of common library (duplication of effort)

   Career path

   Blind use / overselling of models (1)

   Lack of adequate communications infrastructure (3,1)

Priority M&S Problems

- Lack of common library (duplication of effort)
- VV&A (high cost & lack of method)
- Lack of interoperability
- Inadequate resources (funding, manpower/skills, equipment, facilities, management commitment)
- Standards

Prioritized Needs

Resources
- **Management Commitment**
- **Availability(Before, During, After)**
  - **Personnel**
  - **Facilities**
  - **Modeling and Simulation**
  - **Funding**

Management Infrastructure

Library
- **Repository**
  - **Models & Simulations**
  - **Standard Data**
  - **Archives/Reports**
- **Clearing House**
  - **Models &Simulations**
  - **Facilities**
  - **Other**

Prioritized Needs (Continued)

Standards
- **Definitions**
- **Interfaces/Interoperability**
- **Open system Architecture**
- **VV&A**
- **Databases**
- **Scenarios**

Communications
- **Infrastructure**
- **Multi-level Security**

Feedback into M&S process
- **Lessons learned from M&S use (development, DT/OT, etc)**
- **Adequacy, applicability, and utility of M&S used**

Prioritized Needs (Concluded)

Expertise Renewal
- **Centers, labs, facilities, personnel**
- **VV&A support**
- **Continuous M&S improvement**
- **Foster M&S R&D, and availability**

Configuration control
Increased involvement and support of M&S
- **User**
- **Customer**
- **Management**

Determine when/where M&S is appropriate for application
Independent VV&A
- **Referral service**

Rapid M&S reconfiguration capability
User responsive technical support
Joint M&S users group
Detailed execution plan
Rapid, automated data reduction, analysis, and presentation